Physiological parameters and productive performance of rabbit does and their offsprings with dietary supplementation of soy lecithin

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Abstract – The objective of this work was to evaluate the effect of a dietary supplementation with soy lecithin (SL) on the productive performance and blood constituents of rabbit females and their offsprings. A total of 40 rabbits does were distributed into four treatments: control group, no dietary SL inclusion; and three groups with 0.5, 1.0, and 1.5% SL inclusion in the diets. The inclusion of 1.5% SL increased the count of blood cells and hemoglobin concentrations; 0.5–1.0% SL reduced the total cholesterol levels in the blood, as well as the low-density lipoprotein-cholesterol and the activities of the enzymes alkaline phosphatase, aspartate aminotransferase, and alanine aminotransferase, but increased the levels of total lipids, triglycerides, high-density lipoprotein-cholesterol, and the activities of the antioxidant enzymes. Supplementation with 1.0–1.5% SL resulted in higher milk production and heavier litters. Soy lecithin supplementation at 1% improves the physiological parameters and increases the milk production of rabbit does, also improving the performances of their offsprings.

Index terms: animal nutrition, animal reproduction, soybean byproduct.

Parâmetros fisiológicos e desempenho produtivo de coelhas e suas ninhadas com suplementação dietética de lecitina de soja

Resumo – O objetivo deste trabalho foi avaliar o efeito da suplementação dietética com lecitina de soja (LS) sobre o desempenho produtivo e os constituintes sanguíneos de coelhas e suas ninhadas. Um total de 40 coelhas foi distribuído em quatro tratamentos: grupo-controle, sem inclusão de LS; e três grupos com 0,5, 1,0 e 1,5% de inclusão de LS nas dietas. A inclusão de 1,5% de LS aumentou a contagem de células sanguíneas e a concentração de hemoglobina; 0,5–1,0% de LS reduziu os níveis sanguíneos de colesterol total, assim como os de lipoproteína de baixa densidade e as atividades das enzimas fosfatase alcalina, aspartato aminotransferase e alanina aminotransferase, mas aumentou os níveis de lipídios totais, triglicérides, lipoproteína de alta densidade e as atividades das enzimas antioxidantes. A suplementação com LS a 1,0–1,5% resultou em maior produção de leite e ninhadas mais pesadas. A suplementação com lecitina de soja a 1% melhora os parâmetros fisiológicos e aumenta a produção de leite em coelhas, tendo melhorado também o desempenho das ninhadas.

Termos para indexação: nutrição animal, reprodução animal, subproduto da soja.

Introduction

Soy lecithin (SL) is a by-product derived from the processing of soybean oil. It consists of phospholipids and small amounts of glycolipids and carbohydrates (Behr et al., 2011), and it has been used as an emulsifier, antioxidant, and nutritional supplement. The inclusion of SL in animal diets enables the improvement of the antioxidant profile (Attia & Kamel, 2012). The average content of phosphatidylcholine, phosphatidylethanolamine, and inositol phosphatides of SL is 19–21, 8–20, and 20–21%, respectively (Scholfield, 1981), and the content of phosphatidylserine is 0.2–6.3% (Liu & Ma, 2011).

Diets supplemented with SL may result in lower levels of total cholesterol (Attia & Kamel, 2012) and of low-density lipoprotein-cholesterol (LDL-cholesterol) (Mourad et al., 2010). According to LeBlanc et al.

(2003), lecithin can stimulate the bile formation and biliary cholesterol secretion due to the inhibition of the acyl-CoA cholesterol acyltransferase enzyme. Activity of the serum enzymes aspartate aminotransferase and alanine aminotransferase can be decreased due to the SL supplementation in the diets of rabbits (Attia & Kamel, 2012).

In addition, the reproduction performance and kit survival are energetically expensive, and rabbit does are susceptible to an intense body-energy deficit during lactation. The body condition of rabbit females reaches a peak 10 days before kindling and, from this moment on, the reproductive female undergoes the highest-body reserves mobilization (Pascual et al., 2013). Soy lecithin may be useful as it improves the lipid absorption in the gut (Roy et al., 2010), increasing the energy availability to the does that will have a higher-energy supply for milk production.

The objective of this work was to determine the effect of feeding dietary levels of soy lecithin on the physiological status (blood constituents and antioxidant status, as well as enzyme activities) and productive performance of rabbit does and their litter.

Materials and Methods

The present study was conducted at El-Sabahiea Poultry Research Station (Alexandria - Egypt), which is a part of the Animal Production Research Institute, Agriculture Research Center, Ministry of Agriculture, from October, 2009, to April, 2010. The experiment design was approved by the Scientific and Ethics Committee of the Animal Production Research Institute (protocol no. 04-05-03-37).

Forty nulliparous six-month-old V-line doe rabbits, mean body weight 3,583±240 g, were distributed in a completely randomized design, with four dietary treatments, and 10 replicates. Rabbit does were mated with adult male rabbits that were not supplemented with SL.

Rabbit does were housed in a naturally ventilated building and kept in individual cages (60×55×40 cm) equipped with an internal nest-box. Air temperature and relative humidity inside the rabbitry were daily recorded using an electronic digital thermo-hygrometer during the experimental period. The average ambient temperature and relative humidity inside the building were 30.8±0.22°C and 81.4±1.05% respectively.

Rabbits were given pelleted feed and fresh water ad libitum. Rabbit does were fed the supplemented diets, starting from one month before the day they were mated until the 35th day of the 3rd lactation (Table 1).

The reproductive rhythm was semi-intensive according to Attia et al. (2009), and rabbit does were resubjected to natural mating 11 days after delivery (42-day-inter-pupping interval) using 20 bucks with 6 to 7 months of age. Bucks were kept under similar management and hygienic conditions, and fed the same control diet of does, without soy lecithin inclusion (Extracted Oils & Derivatives, Damahour, Egypt). Mating was carried out in the morning at random, thus each female had the same chance to meet with the same male and vice-versa. Each rabbit doe was transferred to the buck's cage for mating (two services within 30 min by the same buck), and returned to its cage after copulation.

Pregnancy was diagnosed by abdominal palpation at 10 days after mating, and those shown to be nonpregnant were subjected to another mating until it became pregnant. The rabbit does that failed to become pregnant after three successive natural matings were discarded from the experiment and replaced by another one.

Treatments consisted of a control group (with no SL inclusion), and SL inclusion levels at 0.5, 1.0, and 1.5% in pelleted diets of (Table 1). The determination of the SL fatty acid profile in the diets was performed with the use of Shimadzu Gas Chromatograph GC-4CM (Shimadzu Corp., Kyoto, Japan), with a field-effect mobility (pFE) connected to a glass column (3 m × 3.1 mm ID) packed with 5% diethylene glycol succinate (DEGS), and equipped with a flame ionization detector (FID) according to Radwan (1978). Fatty acid composition of the experimental diets is listed in Table 2.

Six blood samples per treatment were collected from the marginal ear veins, in heparinized tubes, on the 10th day after mating. Blood plasma was obtained by centrifugation of the samples at 1,750 *g* for 20 min, and then they were stored at -20°C, until use for biochemical analysis. Hemoglobin concentration, red and white blood cell counts, and packed-cell volume (PCV) were recorded; mean cell volume (MCV), mean cell hemoglobin (MCH), and mean cell hemoglobin concentration (MCHC) were referred to as absolute value, in which MCV (fL) = PCV (%) / RBC (10^6 mm^{-3});

MCH (pg/RBC) = Hb (g dL^{-1}) / RBC (10^6 mm^{-3}); and MCHC (gdL^{-1}) = Hb (g dL^{-1}) / PCV (%).

Plasma levels of glucose, total protein, albumin, urea, creatinine, total lipids, phospholipids, triglycerides, total cholesterol, low-density lipoprotein cholesterol (LDL), and high-density lipoprotein cholesterol (HDL), and the activities of the enzymes acid phosphatase, alkaline phosphatase, lactate dehydrogenase, aspartate aminotransferase (AST), and alanine aminotransferase (ALT), were determined using commercial kits produced by Diamond Diagnostics Company (Dokki district, Giza, Egypt). Globulin was calculated by the differences between total protein and albumin.

Table 1. Ingredients and chemical composition of the experimental diets offered to V-line rabbit does.

Ingredient	Dietary soybean lecithin (g kg^{-1})			
	0	05	10	15
Clover hay	400	400	400	400
Yellow corn	100	87	70	55
Barley	130	140	140	140
Wheat bran	150	163	180	200
Soybean meal	175	170	170	165
Soybean lecithin	0.0	5	10	15
Molasses	30	20	15	10
Dicalcium phosphate	8	8	8	8
Sodium chloride	3	3	3	3
Vit+Min Premix[(1)]	3	3	3	3
DL-methionine	1	1	1	1
Total	1000	1000	1000	1000
Analyzed composition				
Dry matter (g kg^{-1})[(2)]	896.7	898.3	897.1	897.5
Crude protein (g kg^{-1})[(2)]	171.8	171.9	174.2	175.2
Crude fiber (g kg^{-1})[(3)]	143.0	144.1	145.3	146.5
Ether extract (g kg^{-1})[(2)]	34.1	39.1	44.1	49.1
Nitrogen free extract (g kg^{-1})[(3)]	560.3	553.1	543.5	544.6
Ash (g kg^{-1})[(2)]	103.3	101.7	102.9	102.5
Digestible energy (kcal kg^{-1})[(3)]	2794	2777	2755	2730
Calcium (g kg^{-1})[(3)]	13.0	13.0	13.0	13.0
Available phosphorus (g kg^{-1})[(3)]	3.6	3.6	3.6	3.6
Total methionine (g kg^{-1})[(3)]	3.6	3.6	3.6	3.6
Total sulfur amino acid (g kg^{-1})[(3)]	6.8	6.8	6.8	6.8
Total lysine (g kg^{-1})[(3)]	9.3	9.3	9.3	9.3

[(1)]Vit+Min Premix (per kilogram) contains: vit. A, 6000 IU; vit. D_3, 450 IU; vit. E, 40 mg; vit. K_3, 1 mg; vit. B_1, 1 mg; vit. B_2, 3 g; vit. B_3, 180 mg; vit. B_6, 39 mg; vit. B_{12}, 2.5 mg; pantothenic acid, 10 mg; biotin, 10 mg; folic acid, 2.5 mg; choline chloride, 1,200 mg; manganese, 15 mg; zinc, 35 mg; iron, 38 mg; copper, 5 mg; cobalt, 0.1 mg; iodine, 0.2 mg; and selenium, 0.05 mg. [(2)]Analyzed values according to the following AOAC (2018a, 2018b, 2018c, 2018d) methods: dry matter, 934.01; crude protein, 945.01; ether extract, 920.39; ash, 942.05. [(3)]Values calculated according to Sauvant et al. (2004), Gaafar et al. (2010), and Khalel et al. (2014).

Total antioxidant capacity and thiobarbituric acid-reactive substances (TBARS) (Costa et al., 2006), glutathione content (Beutler et al., 1963), and the activities of glutathione S-transferase (Habig et al., 1974), glutathione peroxidase (Chiu et al., 1976), and superoxide dismutase (Misra & Fridovich, 1972) where determined to assess the plasma antioxidant activity.

Offspring performances were determined by litter size (alive), kit's body weight at birth, 14th and 28th day of age. The survival rate of offsprings, from kindling to weaning, was also determined. On the parturition day, the doe was separated from the litter and taken to the nest only once a day, in the morning, for 15–20 min, to nurse the kits. At this moment, the doe was weighed before and after nursing, to determine, by difference, the total milk production (Attia et al., 2011) at birth, and at the 14th and 28th days after parturition. Daily feed intake was also recorded.

Data were analyzed using the software Sisvar (Ferreira, 2011), and the Tuckey's test was used to detect significant differences among the means, at 5% probability. Litter size was used as a covariable for milk production analysis. Survival rate data were arc sin-transformed before analysis. The following

Table 2. Fatty acid content of soy lecithin and of the experimental diets (g kg^{-1} total fatty acids).

Fatty acid	Soy lecithin	Soy lecithin in the diets (%)			
		0	5	10	15
Capric acid (C10:0)	-	62.7	36.1	70.7	46.2
Lauric acid (C12:0)	-	61.0	51.0	3.6	4.7
Myristic acid (C14:0)	2.5	47.8	10.4	47.1	56.6
Palmitic acid (C16:0)	172.0	224.8	191.8	130.6	95.9
Palmitoleic acid (C16:1)	3.4	0.0	25.9	30.2	34.2
Stearic acid (C18:0)	52.2	81.7	42.5	35.2	28.9
Oleic acid (C18:1)	228.3	300.1	291.2	263.5	246.5
Linoleic acid (C18:2)	457.0	180.1	283.2	388.7	458.2
Linolenic acid (C18:3)	73.2	-	-	-	-
Arachidic acid (C20:0)	5.1	41.8	67.9	30.4	28.9
Behenic acid (C22:0)	6.3	-	-	-	-
SFA	238.1	519.8	399.7	317.6	295.4
UFA	761.9	480.1	600.3	682.4	738.9
PUFA	530.2	180.1	283.2	388.7	458.2
MUFA	231.7	300.1	317.1	293.7	280.7
SFA/UFA	0.31	1.08	0.66	0.47	0.39
MUFA/UFA	0.30	0.62	0.53	0.43	0.38
MUFA/PUFA	0.44	1.67	1.12	0.76	0.61
PUFA/UFA	0.69	0.37	0.47	0.57	0.62

SFA, saturated fatty acid; UFA, unsaturated fatty acid; PUFA, polyunsaturated fatty acid; MUFA, monounsaturated fatty acid.

statistical model was used: $Y_{ij} = \mu + t_i + \varepsilon_{ij}$, where Y_{ij} is the dependent variable; μ is the general mean; t_i is the effect of the SL level; and ε_{ij} is the random experimental error.

Results and Discussion

Soy lecithin inclusion at 0.5% was enough to increase the red blood cells; 1% inclusion resulted in higher values of hemoglobin and of mean cell hemoglobin concentration, and lower values of mean cell volume; and 1.5% improved white cell counts (Table 3).

The use of rations containing 0.5% SL [+57% polyunsaturated fatty acid (PUFA), in comparison to the control group] was enough to increase the red blood cell counts, in comparison to white blood cell ones. The content of PUFA in red cell membrane is linearly related to the consumption, but the membrane of white cells does not show a dose-responsive increase in PUFA (Witte et al., 2010). The high-PUFA content in blood cell membranes and the high-iron and O_2 concentration in hemoglobin make these cells sensible to oxidative injuries (Hou et al., 2014) caused by different external or internal stimuli. Soy lecithin showed a positive effect on blood cells due to its phospholipids content (Attia et al., 2009; Attia & Kamel 2012) which is incorporated into these cell membranes (Faber et al., 2011), reducing the oxidative damage on these cells, and avoiding their apoptosis and, hence, improving the hemoglobin and mean cell hemoglobin concentration values.

Compared to the control group, the levels of total lipid (+17.66%), triglycerides (+16.10%), and HDL (+33.93%) increased when SL was added in the diets at 1.5, 0.5%, and 1.0%, respectively; and reduced total cholesterol (-7.20%) and LDL (-17.08%) concentrations, when it was included at 1.0 and 0.5%, respectively (Table 4). The inclusion of 1% SL resulted in an increase of serum total lipids and triglycerides content. Lecithin is a mixture of glycolipids, triglycerides, and phospholipids, and acts as an emulsifier, which increases the fat absorption in the intestines, as shown by Huang et al. (2008), in broilers, and Attia et al. (2009), in hens.

Soy lecithin decreased the total cholesterol (-7.51%) and the fraction LDL (-26.24%), but increased the fraction HDL (+33.93%). Some researchers showed that a diet containing lecithin modifies the cholesterol homeostasis in the liver, reducing the excess LDL, and promoting the synthesis of a great amount of HDL in the liver (Mourad et al., 2010). There is also an inhibition of the acyl-CoA cholesterol acyltransferase (ACAT) by the SL consumption, and lower ACAT activity was associated with lower, free, and esterified cholesterol content, which may be rapidly directed to the elimination in the bile, or may be converted into biliar acids (LeBlanc et al., 2003). Soy lecithin lowers the serum total cholesterol when fed in

Table 3. Effect of dietary levels of soybean lecithin (SL) inclusion on the hematological constituents of V-Line rabbit does[1].

Parameter	SL in the diets (%)				p-value	SEM
	0.0	0.5	1.0	1.5		
Packed cell volume (%)	37.8	38.1	37.7	37.4	0.624	0.41
WBC (10^3 µL^{-1})	7.96b	8.22b	8.17b	8.88a	0.001	0.14
RBC (10^6 µL^{-1})	5.67b	5.95a	6.12a	6.12a	0.001	0.06
Hemoglobin (g dL^{-1})	11.7b	11.9ab	12.3a	12.33a	0.004	0.14
MCV (fL)	66.7a	64.5ab	61.5b	61.0b	0.001	1.08
MCH (pg/RBC)	20.6	20.2	20.2	20.3	0.821	0.34
MCHC (g dL^{-1})	30.8b	31.4ab	32.7a	33.2a	0.006	0.52

[1]Means followed by different letters, in the lines, indicate significant differences by Tuckey's test, at 5% probability. SEM, standard error of the means; n= 6 per treatment; WBC, white blood cells; RBC, red blood cells; MCV, mean cell volume; MCH, mean cell hemoglobin; MCHC, mean cell hemoglobin concentrations.

Table 4. Effect of dietary concentrations of soybean lecithin (SL) on the biochemical constituents of blood plasma of V-Line rabbit does[1].

Parameter	SL in the diets (%)				p-value	SEM
	0.0	0.5	1.0	1.5		
Glucose (mg dL^{-1})	112	111	117	116	0.186	2.0
Total protein (g dL^{-1})	6.63	6.56	6.68	6.66	0.425	0.05
Albumin (g dL^{-1})	3.43	3.45	3.41	3.55	0.561	0.07
Globulin (g dL^{-1})	3.20	3.12	3.27	3.12	0.252	0.06
Urea (mg dL^{-1})	45.2	44.1	43.4	42.5	0.373	1.09
Creatinine (mg dL^{-1})	1.35	1.30	1.30	1.31	0.792	0.05
Urea/creatinine	33.2	34.2	34.0	32.2	0.052	0.73
Total lipid (mg dL^{-1})	453b	501ab	500ab	533a	0.005	13.0
Phospholipids (mg dL^{-1})	185	205	215	221	0.086	10.0
Triglycerides (mg dL^{-1})	38.5b	44.7a	46.2a	48.1a	0.002	1.32
Cholesterol (mg dL^{-1})	125a	121a	116b	115b	0.003	2.0
HDL (mg dL^{-1})	44.8b	47.9b	60.0a	57.2a	0.001	2.46
LDL (mg dL^{-1})	64.4a	53.4b	47.5b	49.0b	0.006	3.19

[1]Means followed by different letters, in the lines, indicate significant differences, by Tuckey's test, at 5% probability. SEM, standard error of the means; n= 6 per treatment; HDL, high-density lipoprotein cholesterol; LDL, low-density lipoprotein cholesterol.

hypercholesterolemic diets by laying hens (Attia et al., 2009) and rabbits (Attia & Kamel, 2012). In addition, dietary PUFAs may also reduce the plasma cholesterol (Ramprasath et al., 2012).

Similarly, Huang et al. (2008) found that dietary SL lowered the total cholesterol, triglycerides, and LDL, but increased HDL in broilers. Attia et al. (2009) also indicated that lecithin supplementation significantly increased the plasma-total lipid, but decreased the plasma cholesterol, while it did not significantly affect the plasma total protein of laying hens. The contradiction among the mentioned results regarding the effects of SL on plasma cholesterol, LDL, and HDL, could be attributed to the animal species, SL levels, and the physiological condition of the animal.

Supplementation with SL also increased the activities of the enzymes in the blood. A higher activity of the acid phosphatase, glutathione S-transferase, and superoxide dismutase, as well as glutathione, and glutathione peroxidase, and the total antioxidant capacity were found with 0.5, 1.0, and 1.5% SL inclusion, respectively. When included at 0.5%, SL resulted in lower activity of the enzymes AST and TBARS values; and ALP and ALT activities were reduced with 1% SL inclusion (Table 5).

Since PUFAs are highly unsaturated, and susceptible to autoxidation, SL supplementation increased the activities of the antioxidant enzymes and TBARS levels. Low-TBARS levels due to the increasing SL levels may be the result of the higher-activities of the antioxidant enzymes that inhibited the lipid peroxidation. It is known that oxidative stress results in reactive oxygen species formation and in decreased antioxidant reserve (Yoon & Park, 2014). Superoxide dismutase is an important defense enzyme that catalyzes the reduction of hydrogen peroxides and protects the tissues against highly reactive oxygen species, and glutathione, glutathione S-transferase, and glutathione peroxidase also catalyze the reduction of hydrogen peroxides and hydroxiperoxides to nontoxic products (Hosseini-Vashan et al., 2012). There was a reduction in the activities of alanine aminotransferase and aspartate aminotransferase. These enzymes are important liver markers, and the results suggest a protective effect of SL on liver cells mainly due to its phosphatidylcholine content (Jung et al*.,* 2013).

There was no effect of the treatments on the feed intake of the females. Due to the SL inclusion at 1.0%, there was an improvement on the litter size and kit weight at birth (+15.8 and 11.0%), and for ages at the 14th day (+35.3 and 18.4%), and at the 28th day (+40.5 and 7.4%). Soy lecithin at 1.0% improved the survival rate in all evaluated ages. Milk production was improved in 28.32, 24.5, and 19.7% at birth, and at the 14th and 28th days after birth, respectively, due to 1.0 and 1.5% SL supplementation (Table 6).

Supplementation with SL improved the milk production and litter performance. PUFA content increased up to 154% in diets with 1.5% SL, and digestibility of dietary fats was influenced by the fatty acid profile with a positive relationship between degree of unsaturation of fats and their digestibility

Table 5. Effect of dietary concentrations of soybean lecithin on the enzymes and antioxidant profile of blood plasma of V-Line rabbit does[(1)].

Parameter	Soybean lecithin in the diets (%)				p-value	SEM
	0.0	0.5	1.0	1.5		
Alkaline phosphatase (ALP, IU L^{-1})	185.4a	153.0b	176.2a	159.3ab	0.017	7.20
Acid phosphatase (ACP, IU L^{-1})	47.8b	52.0a	54.6a	55.3a	0.003	1.34
Lactate dehydrogenase (LDH, U L^{-1})	275.1	287.4	301.3	326.4	0.127	10.81
Aspartate aminotransferase (AST, U L^{-1})	55.5a	49.3b	47.0b	45.5b	0.016	2.09
Alanine aminotransferase (ALT, U L^{-1})	29.0a	26.2ab	24.5bc	22.7c	0.001	1.53
Total antioxidant capacity (TAC, mm L^{-1})	141.3c	154.4b	172.3a	171.8a	0.001	1.94
Thiobarbituric acid-reactive substances (TBARS, nmol mL)	1.14a	0.949b	0.982b	0.963b	0.001	0.01
Glutathione-S-transferase (GST, IU)	1.02d	1.44c	1.61a	1.54b	0.001	0.004
Glutathione (GSH, mg dL^{-1})	14.1d	17.96c	25.30b	28.50a	0.001	0.456
Glutathione peroxidase (GPx, mg L^{-1})	4.47b	4.48b	4.74b	5.22a	0.001	0.116
Superoxide dismutase (SOD, IU)	7.38ab	7.21b	7.65a	7.74a	0.010	0.111

[(1)]Means followed by different letters, in the lines, indicate significant differences by Tuckey's test, at 5% probability. SEM, standard error of the means; n= 6 per treatment; TBARS, thiobarbituric acid-reactive substances.

Table 6. Litter size, body weight, and survival rate of the offsprings, and milk production of rabbit does that received levels of soybean lecithin in their diets[1].

Parameter	Soybean lecithin in the diets (%)				p-value	SEM
	0.0	0.5	1.0	1.5		
			At birth			
Litter size	7.56c	8.28b	9.59a	9.82a	0.001	0.17
Body weight (g)	52.3c	56.1c	58.1a	58.6a	0.001	0.61
Milk production (g per day)	47.67c	52.67b	61.17a	61.67a	0.001	0.66
Feed intake (g per day)	191.4	185.8	181.4	177.3	0.826	11.0
			At the14th day after birth			
Litter size	6.40c	7.05b	8.66a	8.78a	0.001	0.14
Body weight (g)	223c	238b	264a	269a	0.001	4.42
Survival rate (%)	85.80b	85.99b	88.55b	92.02a	0.001	1.01
Milk production (g per day)	155.1c	168.4b	180.7ab	193.1a	0.001	4.69
Feed intake (g per day)	191.7	187.0	182.6	184.1	0.941	11.1
			At the 28th day after birth			
Litter size	5.97c	6.82b	8.39a	8.39a	0.001	0.14
Body weight (g)	484b	505ab	520a	527a	0.002	8.58
Survival rate (%)	79.6c	82.9cb	86.1ab	88.3a	0.001	1.28
Milk production (g per day)	102.3c	104.5c	114.8b	122.4a	0.001	2.62
Feed intake (g per day)	207.9	196.7	193.5	178.8	0.155	8.93

[1]Means followed by different letters, in the lines, indicate significant differences by Tuckey's test, at 5% probability. SEM, standard error of the means; n= 10 per treatment.

(Droke & Lukaski, 2008). In addition, as an emulsifier, SL promotes incorporation of fatty acids in micelles, and increases fat absorption in the gut (Roy et al., 2010), thereby increasing the energy utilization by the does. Energy deficit may be responsible for the lower size and weight of the litters at the birth. During lactation, the energy output is not compensated by the feed intake, and the fat store needs to be mobilized. If rabbit does can better use the ingested energy, they will have a higher-energy supply for milk production; consequently, this results in higher-survival rate and kit weight. This effect was seen at the 14th and 28th days of the lactation period due to the SL supplementation.

Conclusion

Soy lecithin supplementation at 1% improves the hematological, biochemical, and antioxidant status, along with the increased milk production, and improves offspring growth performance up to weaning.

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Received on April 3, 2017 and accepted on December 1º, 2017